# ON THE ENERGY INVOLVED IN THE RECENT OUTBURST OF BETA CETI.

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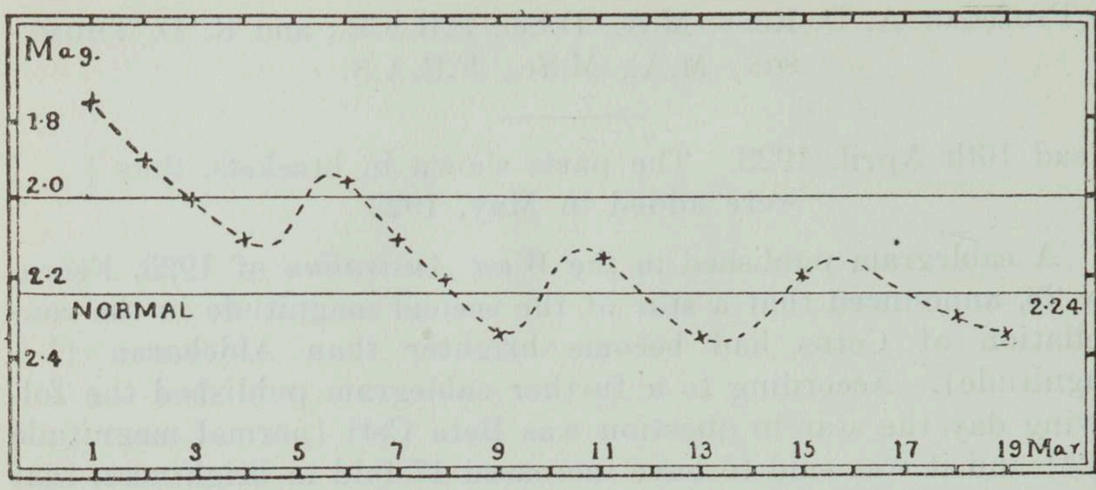
Read 10th April, 1923. The parts shown in brackets, thus [ ] were added in May, 1923.

A cablegram published in the *West Australian* of 1923, February 28, announced that a star of the second magnitude in the constellation of Cetus had become brighter than Aldebaran (1·1 magnitude). According to a further cablegram published the following day the star in question was Beta Ceti (normal magnitude 2·24) and it was said to have increased 17-fold in brightness, that is to —0·7 magnitude. [It now transpires that only three estimates were obtained in Europe of the brightening of the star. The discovery was made by Mr. William N. Abbott at Athens on 1923, Feb. 13. The star was "superior in magnitude to Alpha Tauri (Aldebaran)" and "in the immediate vicinity no other object, except the planet Mars, was comparable in magnitude."* On Feb. 16 Mr. Abbott found Beta Ceti "to have greatly decreased since the night of the 13th. Its magnitude was inferior to Aldebaran (1.1), which it had surpassed on the 13th February, but superior to Gamma Cassiopeiae of 2·24 magnitude."* Mr. Abbott telegraphed his discovery on February 14 to M. Flammarion at Paris, who asked his assistant M. Quénisset at Juvisy to verify the observation. On February 23 M. Quénisset found Beta Ceti as at least of the first magnitude.†]

The authors made a series of careful visual estimates of the brightness of the star on every clear evening from March 1 until by the third week of the month the star came too close to the sun to permit useful observation. The observations were made independently, one set being obtained generally from South Perth and the other from West Perth, although occasional observations had to be conducted from Cottesloe, when haze or smoke would otherwise have vitiated the estimates. Allowance for atmospheric absorption was tested by observations of Alpha Phœnicis—a star of similar spectral type (viz. Ko). As a rule about ten comparison stars were used on each occasion, covering a range of about 0·6 or 0·7 magnitude. The average difference between the two individual determinations on each night was under 0·1 magnitude, and exceeded 0·2 magnitude on only one night (March 13, determinations 2·2 and 2·5).

* Observatory, 1923, April. † L'Astronomie, 1923, March.

The following are the means of the determinations:—Mar. 1, 1·75; Mar. 2, 1·9; Mar. 3, 2·0; Mar. 4, 2·1; Mar. 6, 1·95; Mar. 7, 2·1; Mar. 8, 2·2; Mar. 9, 2·35; Mar. 11, 2·15; Mar. 13, 2·35; Mar. 15, 2·2; Mar. 18, 2·3; Mar. 19, 2·35; [May 3, 2·25]. These values are plotted in the accompanying diagram. It will be




Variation in brightness of Beta Ceti.

observed that the light intensity in March was settling down to its normal value of 2·24 in a series of minor fluctuations having a five day period with maxima about March 6, 11, 16, and minima about March 4, 9, 14. [It is interesting to note that carrying back this oscillation we would have maxima in Europe about February 14 (or 13), and 24 (or 23), and a minimum about February 17 (or 16). It is possible that this explains the relative brightnesses found by Mr. Abbott and M. Quénisset.]

Remembering that an increase of one magnitude in the brightness of a star means an increase of 151 per cent. in the light, it appears that in its outburst Beta Ceti has radiated an extra amount of light equivalent to at least 20 days' normal output. The star's spectroscopic parallax is 0·042″,* corresponding to a distance of about 78 light years. Hence, as the sun's stellar magnitude is —26·6, and it is equivalent to 1,575 $\times$ $10^{24}$ candles in total brightness, we get Beta Ceti at normal as equal to 115 $\times$ $10^{27}$ candles. Now Rayleigh has found that the luminous radiation from a standard candle equals 2·2 foot-pounds per minute.† Hence the normal light of Beta Ceti represents an output of 37 $\times$ $10^{31}$ ft.-lbs. per minute. Therefore the extra luminous energy radiated in the outburst must have been about 74 $\times$ $10^{32}$ ft.-lbs. This is only part of the total energy radiated. In radiation from a body at a temperature of about 8,000° C. the luminous energy amounts to just over 40 per cent. of the total radiant energy. For higher or lower temperatures the luminous energy is a smaller proportion, being only 20 per cent. at about 3,500° or 14,000° C. We shall

* Contributions from Mt. Wilson Observatory.
† Rayleigh; Collected Papers. Angstrom's value is about double Rayleigh's.

not be far out if we assume 30 per cent. in the case of Beta Ceti, thereby finding that the extra output of energy was about $24 \times 10^{33}$ ft.-lbs. in all, or at the average rate of 25 billion billion horsepower over a three-week period.

It has been suggested that such an outburst might be due to the collision of the star with another celestial body. Beta Ceti is a giant star* with a mass say 50 per cent. greater than the sun's mass, and a radius say 40 times the sun's radius. A body drawn to it from an indefinitely great distance would therefore fall into it at a speed of about 74 miles per second.† The mass of this body, in order to provide the necessary kinetic energy for the subsequent radiation, would require to be about $45 \times 10^{20}$ tons. The Earth's mass is about $59 \times 10^{20}$ tons, while Jupiter is over 300 times larger and the planetoid Ceres about 6,000 times smaller. If then the outburst has been caused by the impact of another celestial body, that body has been of planetary size. Stellar masses would have given an effect of order a million times greater and cometary masses an effect of order a million times smaller.

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* Contributions from Mt. Wilson Observatory.

† The parabolic velocity, or velocity from infinity, is 380 miles per second for the sun. Moulton, Celestial Mechanics.